COMMERICIALIZATION AND DMS EFFORTS AT ROME LABORATORY

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BACKGROUND

- **Rome Laboratory**
  - **MIL-STD-883 Test Methods**
  - **MIL-M-38510 Qualified Parts List (QPL) for ICs**
  - **MIL-I-38535 Qualified Manufacturer's List (QML) for ICs**
    - » **Accommodates Offshore Manufacturing & PEMS**
  - **Analytical & Environmental Test Capabilities**
    - » **Scanning Acoustic Microscopy (SAM)**
    - » **Scanning Electron Microscope (SEM)**
    - » **Destructive Physical Analysis**
    - » **85C/85%RH, Autoclave**
    - » **Highly Accelerated Stress Test (HAST)**
    - » **Temperature Cycle**

SEMICONDUCTOR PACKAGING TECHNOLOGY ASSESSMENT

- **Insertion of PEMs should be accelerated in appropriate application areas**
- **PEMs could be readily used in non-critical, relatively benign applications**
- **Concerns for PEM long term storage life in extreme temperature and humidity environments need to be addressed**
- **A reliability physics approach should be adopted to determine root causes of failure**

OVERCOMING BARRIERS

- **DoD must act to overcome design conservatism in the absence of appropriate performance and reliability information**

- **The following projects to collect and distribute better data are recommended:**
  - **Define the environment in which ICs will perform**
  - **Characterize commercial product performance under various environmental conditions and in actual fielded use**
  - **Coordinate IC characterization projects and dissemination of results**

COST EFFECTIVE TESTS FOR SELECTING PEMs

Problem:

- Effects of Pre-conditioning on reliability
- Appropriateness of Peck Acceleration Model
- Reliability differences: DIP vs. SMT, Analog vs. Digital, Vendor Quality

Attributes:

- Analog and Digital Devices
- Low Lead Count DIP & SMT Packages
- Hermetic DIP Control Packages
- Five & Six Manufacturers for Analog and Digital Respectively
- PEMs Purchased through Distribution

Payoff:

- Low risk decisions regarding suitability/cost effectiveness of commercial products for diverse military system applications

- Determination of value added tests for assuring PEM performance in military use conditions

ESC/JTIDS & EN-IB
BEST COMMERCIAL/INDUSTRY
COMPONENTS AND PRACTICES

- **Objective:**
  - **Investigate differences in quality and reliability between PWAs built using commercial components and processes versus military components & processes**
  - **Develop recommendations and guidelines for using commercial components & processes for ESC/JTIDS, Air Force, DoD**
- **Approach:**
  - **Six Cell Test Matrix, Four PWAs each. Six iterations of testing**
  - **Test sequence/iteration: 48Hrs (85°C /85%RH) 208 hrs temp/vib (52 cycles)**
  - **Temperature (-54°C to 110°C) Vibration: 6.0Grms, 38 min/cycle**

FAILURE SUMMARY BY COMPONENT TYPE

	Military Process Line	Commercial Process Line
Components (Mil)	Number of Failures	Number of Failures
Active	Switch: 1 PLD: 1	0
Passive	Inductors: 6 Capacitors: 2	Inductors: 6
VTF/ SAW	VTF: 6 SAW: 5	VTO: 1
Components (Mil Temp)		
Active	0	Diode: 1
Passive	Capacitor: 1	Capacitor: 1
Components (Comm.)		
Active	PLD: 1	0
Passive	0	0

MTBF CALCULATIONS ALL ACTIVE PARTS WITH MULTIPLE (2 or 3) LEVEL SUBSTITUTION

PARTS	Total Parts [1]	Total Hours [3]	Total Part Hours	Failures	MTBF
MIL	160	(6*208)	199,680	1	199,680
MIL-T	240	(6*208)	299,520	1	299,520
COM	80	(6*208)	99,840	0	[2] 143,654
Hermetic	160	(6*208)	199,680	1	199,680
Plastic	80	(6*208)	99,840	0	[2] 143,654

1. The part totals were calculated by multiplying sum of the part totals from Active Parts Table by 4
2. The MTBF for the commercial parts was calculated based on the χ^2 distribution.
3. The total hours is the number of iteration times the number of hours per temperature/ vibration iteration.

DELAMINATION OF PEMs ON BOARDS ASSEMBLED USING MILITARY AND COMMERCIAL PROCESSES

MILITARY BOARD LEVEL ASSEMBLY SHOWS MORE DELAMINATION (RED) THAN COMMERCIAL ASSEMBLY, AS SHOWN BY C-SAM IMAGES. CAUSE TRACED TO ADDITIONAL ENVIRONMENTAL TEST ON MILITARY ASSEMBLY. ALL OTHER ASSEMBLY PROCESSES THE SAME.

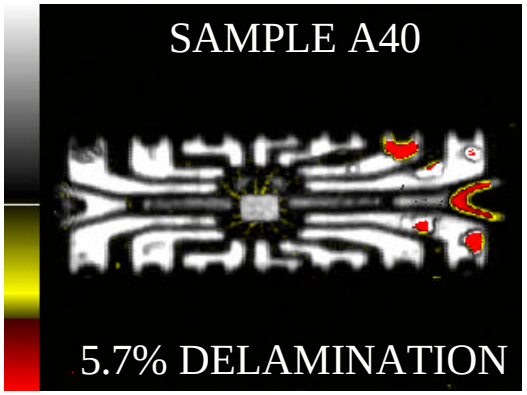
BCIC&P, PEMs and JTIDS

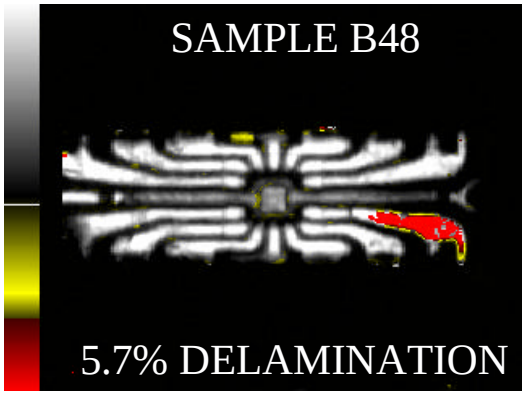
- **BCIC&P test data identified additional areas of concern for using PEMs on JTIDS**
- **BCIC&P component failure analysis identified a 20-25% increase in delamination in PEMs assembled on the military line versus commercial line**
- **As a result, it became evident that an overall policy for implementing PEMs on JTIDS was necessary. Contractors Best Commercial Practices would be leveraged as much as possible. Policy must address the following areas:**
  - **Manufacturing Parts Control Program**
  - **Handling & Storage of PEM devices**
  - **Assembly of PEMs on to next higher level assemblies**

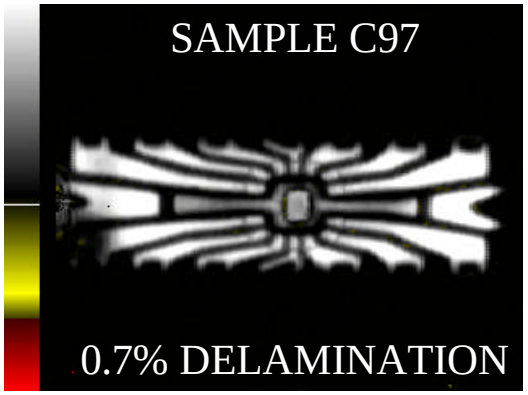
ROME LABORATORY
FINDINGS ON USE OF PEMs

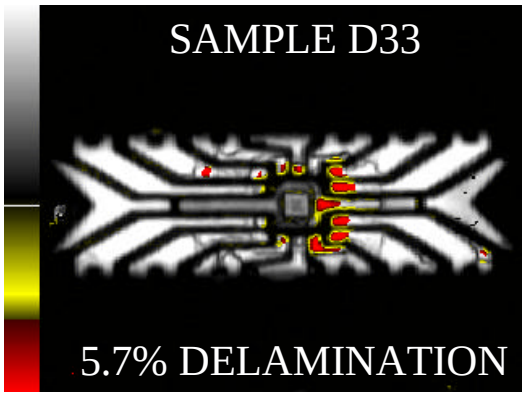
- **Quality of vendors is variable**
  - **Physical analysis should be performed when evaluating vendors**
- **Detection of delamination in PEMs requires Acoustic Microscopy and dye penetrant tests**
- **Preconditioning (simulates the board soldering process) must be performed before any reliability tests**
  - **Ensure consistency with assembly/assembled parts, in regards to:**
    - **» Flux**
    - **» Soldering profile**
    - **» Cleaning process**
  - **Impacts reliability test results**
- **Board level assembly procedures must be re-evaluated when transitioning from hermetic packaging to PEMs**

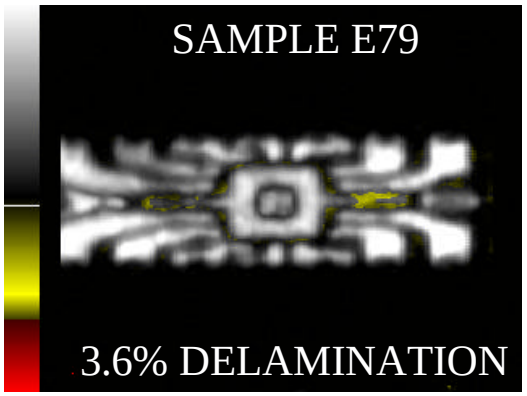
PERCENT DELAMINATION FOR SIX MANUFACTURERS' PRODUCT (AS RECEIVED)

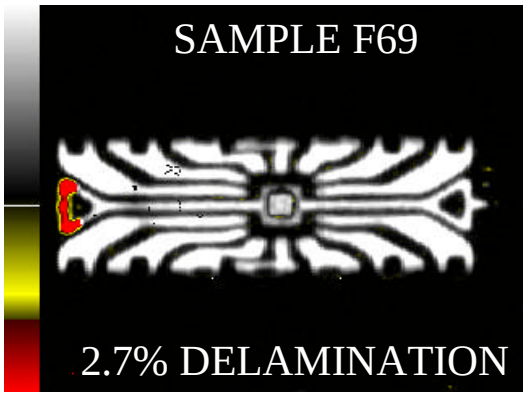






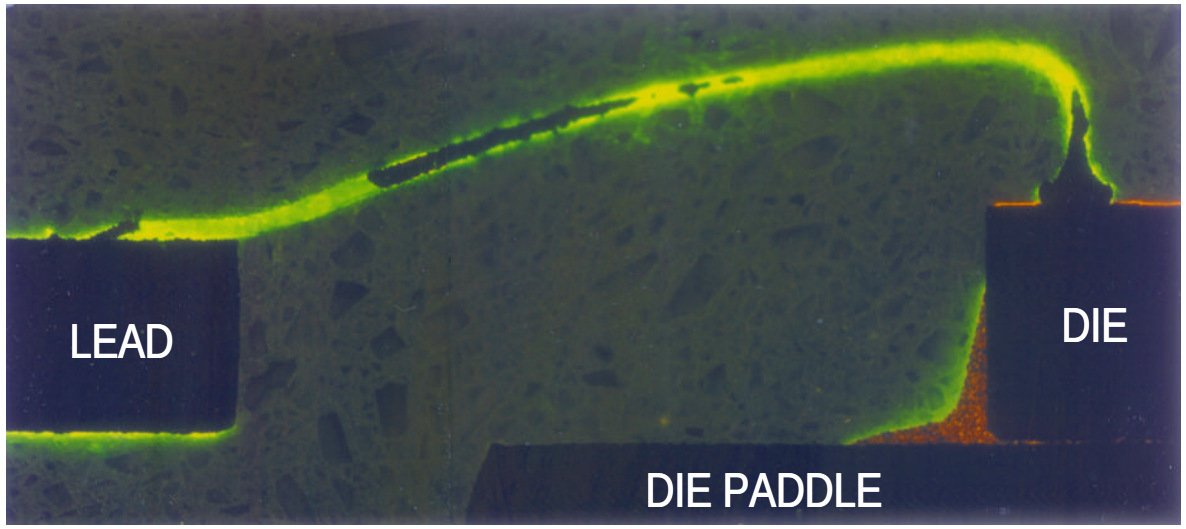


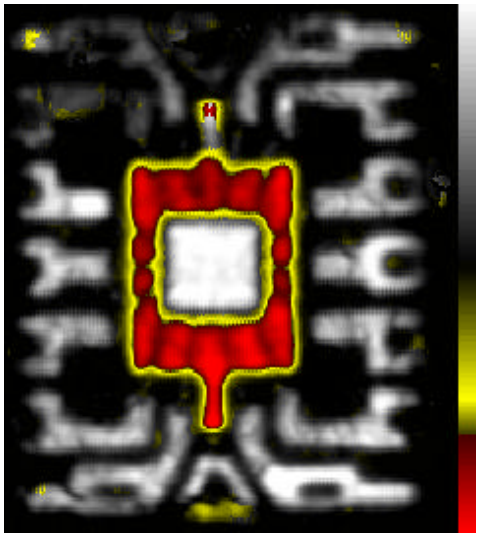




CD4011 IN 14LEAD DUAL IN-LINE PACKAGES BY
HARRIS, MOTOROLA, NATIONAL, PHILIPS, SGS-THOMSOM, AND TOSHIBA

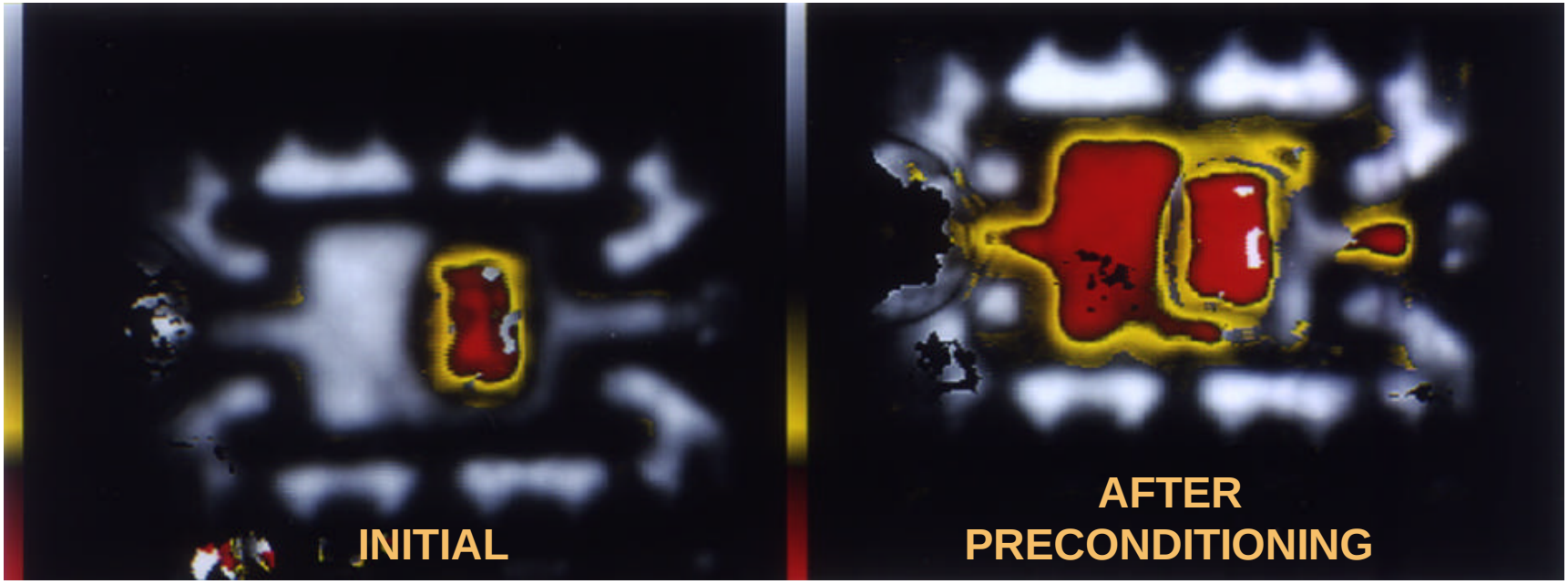
PATHWAYS FOR CONTAMINATION DETECTABLE BY DYE PENETRANT TEST





DYE PENETRANT FLUORESCING ALONG POTENTIAL CONTAMINATION PATHWAYS IN A PLASTIC ENCAPSULATED MICROCIRCUIT AFTER PRE-CONDITIONING.

EFFECTS OF PRECONDITIONING ON PEMs



PRECONDITIONING (SIMULATED SOLDERING) SHOWS DELAMINATION (RED) CHANGES, AS SHOWN BY SCANNING ACOUSTIC MICROSCOPY IMAGES.

PLASTIC ENCAPSULATED MICROCIRCUIT LONG TERM STORAGE PROGRAM

Problem:

- Commercial Plastic Encapsulated Microcircuits (PEMs) targeted for military applications (e.g. missiles) lack reliability data for long term storage applications

Accomplishment:

- 5 yr joint RL/Army MICOM program
- 300 Parts/5 comm suppliers (gates)
- 4 diverse storage environments measured (benign, tropical, desert, arctic)

Payoff:

- Low Risk /Cost Effective Approach for use of Commercial Products in Harsh Dormant Storage Conditions
- Define Maintenance Concepts, Storage Requirements, Design Considerations

LONG TERM STORAGE CLIMATIC DATA AND RESULTS

Storage Location	Temperature *		Relative Humidity (%) *		Failures/Total Tested	Predicted Life **
	Max (°C)	Min (°C)	Maximum	Minimum		
Redstone (Benign)	45	-12	52	<5	0 / 250	19.45 YRS
Yuma (Desert)	51	0	69	13	1 / 250	4.53 YRS
Eglin (Tropical)	36	-6	46	<5	1 / 250	73.0 YRS
Rome (Arctic)	32	-19	43	<5	1 / 250	139.0 YRS
Jeb Stewart (Ship)	TBD	TBD	TBD	TBD	TBD	TBD

*** Temperature and relative humidity inside container with desiccant**

**** Based on Industry Standard Acceleration Reliability Model, No failures after 1000 hours of 85C/85%RH, Ea = 0.9eV, Worst Case Environmental Conditions**

GUIDE TO MILITARY USE OF COMMERCIAL PARTS

- **Published December 1996**
- **Provides information for both military program offices and manufacturers on Best Commercial Practices**
- **Defines an effective parts management program**
- **Discusses device reliability & quality test methods and their significance**
- **Provides reliability case studies**

RAC Data Sharing Consortium (DSC)

- **Compiles data on parts and systems for reliability assessments**
- **Types of data being collected include screening, qualification, failure analysis and field performance of components and systems**
- **Data repository accessible to members (http://rome.iitri.com/consortium)**
- **Provide data used to benchmark Best Commercial Practices**
- **Government membership at no cost.**

DSC - Current Membership

Company	Membership Status	Company	Membership Status	Company	Membership Status
Aerospatial	Distribution	ELDEC	**Steering Committee**	Lockheed Martin Control Systems	Distribution
Allied Signal	**Steering Committee**	GEC - Marconi	Distribution	Lockheed Martin Electronics & Missiles	Distribution
AMD	Distribution	Honeywell MAVD	Distribution	Lockheed Martin Missiles & Space	Distribution
Ametek Aerospace	Distribution	Honeywell ATS	**Steering Committee**	Los Angeles AFB	Distribution
Autronics Corporation	Distribution	Hughes	Distribution	McDonnell Douglas	Distribution
Ball Aerospace	Paying	Hughes Avicom International	Distribution	Motorola	Distribution
BF Goodrich Aerospace	Distribution	Hughes Space & Communications	Distribution	Page Aerospace	Distribution
BFG Rosemount	Distribution	Intertechnique	Distribution	Philips	Distribution
Boeing	**Steering Committee**	Koito Mfg Company	Distribution	Raytheon	Distribution
Boeing - CAS	Pending	Korry Electronics	Pending	Rockwell International	Distribution
Continental Viking Laboratories	Distribution	Litton APD	Distribution	Smiths Industries	Pending
Delco Electronics	Distribution	Lockheed Martin	Pending	Sundstrand	**Steering Committee**
E-Systems	Distribution	Lockheed Martin Astronautics	Distribution	UTC Hamilton Standard	Distribution

DMS EFFORTS

- **JTIDS Program**
  - **Risk Assessment of DMS Parts**
  - **Redesign Maintaining Board Level Form, Fit, Function**
- **AWACS Program**
  - **Assessing Use of VHDL for Board Redesign using FPGAs**
- **F-16 Program**
  - **Working With Lockheed-Martin on a Demonstration of using VHDL for Board Level Redesign**
    - **» VHDL Design Environment for Legecy Electronics (VDELE)**
    - **» Rome Lab Tools Used to Capture Design from Test Program Sets (TPS)**
    - **» Rome Lab Design Verification Approach Based on Fault Grading**

DMS AND COTS

- **COTS Doesn't Solve the DMS Problem**
  - **COTS have 3-5 year Life Cycle (and Getting Shorter)**
  - **If Design Cycle > 5 years, DMS before Production**

- **Recommendation**
  - **Use VHDL to Document Design Whether or Not COTS is used in the System**
    - » **System Configuration is Preserved**
    - » **TECHNOLOGY TRANSPARENT**

CONCLUSIONS

- **PEMS Can Be Viable For DoD Systems**
  - **Need to Be Aware of:**
    - » **Manufacturer's Parts Control Program**
    - » **How PEMS aree Handled & Stored**
    - » **Procedures used to Assemble PEMS on Next Level Assembly**

- **DMS SOlutions**
  - **VHDL is being used on Several Air Force Programs**
  - **COTS Not Necessarily the Answer**
  - **Need to Become TECHNOLOGY TRANSPARENT**